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ABSTRACT

Reported are seven primary recommendations on national science policy made by the Task Force on Science Policy to the President. From a review of the Federal Government's existing science policy (in 1969), problems and opportunities considered as inputs to the legislative and executive science program for 1970 were selected. A criterion for selection was long-term impact on national policies. The particular issues selected include: (1) science, technology, and national goals; (2) expanding applications for science and technology; (3) management of direct federal support for basic and applied research; (4) stimulating technological innovation by private institutions; (5) science policy as related to national security; (6) international initiatives utilizing science and technology; and (7) continuing development of science policy. (Author/RS)

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# SCIENCE AND TECHNOLOGY: TOOLS FOR PROGRESS

The Report of
The President's Task Force on
Science Policy

April 1970

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# SCIENCE AND TECHNOLOGY: TOOLS FOR PROGRESS

The Report of
The President's Task Force on
Science Policy

April 1970

December 10, 1969

The President
The White House
Washington, D. C.

Mr. President:

This is a time of urusual need and unusual reward for Presidential leadership in bringing the tools of science and technology more effectively to bear on critical social urban, and environmental problems, as part of a broader program to properly relate science policy to the Nation's goals and purposes. This is the principal conclusion of your Task Force on Science Policy, which is pleased to present its report, as requested.

Our report focuses on a few issues and opportunities in science policy which are of current urgency and long range significance, and which we believe are ready for decision and action. The wisdom and vigor of actions taken on science policy during the next few years can have a major impact on the Nation's future for many decades.

I share with the members of the Science Policy Task Force the hope that our report will prove useful to you and your Administration as you consider ways of bridging the gap between the promise of science and technology on the one hand and the needs of our Nation and of all mankind on the other.

Respectfully,

Ruben F. Mettler

Ruben F. Mettler, Chairman
Science Policy Task Force

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# *Preface*

The Task Force on Science Policy was asked to conduct a review of the Federal Government's present science policy, and to make recommendations as to its future scope and direction. In carrying out its assignment, the Task Force has drawn from a number of excellent analyses and reports issued recently on various aspects of science policy.

The term "science policy" has been taken to cover all of science, technology, engineering, and basic and applied research and development, as performed in Government, industrial, academic, and other institutions. "Science and technology," as used in this report, include the social and behavioral sciences, as well as the natural and physical sciences.

From the board scope of national science policy, the Task Force has selected a few urgent problems and opportunities which the President and his Administration could consider as inputs in developing a program of legislative and executive action for 1970. There are many important areas—health care, education, urban and environmental problems, for example—in which national policies directed toward the more effective application of science and technology are urgently needed. The Task Force is conscious of the fact that its selection of a limited number of these issues will, of course, omit others of continuing significance and interest to many groups both in Government and in academic and industrial circles.

Although the Task Force focused on actions that could be undertaken by the Administration in the immediate future, this does not mean that the issues selected have only near-term implications. On the contrary, a criterion for selection was long-term impact.

The Task Force elected to avoid making this report another plea for more money for specific projects, although urgent and critical funding problems do exist in many areas of science and technology today. All aspects of science policy are currently strongly influenced by the fact that, after years of rapid growth, Federal funds for the support of basic research and academic science have leveled or, considering the effects of inflation, decreased in recent years. Intense budget pressures and very difficult priority choices exist. Recognizing the budget constraints which face the Administration, the Task Force felt that it could make the most useful contribution by concentrating on policy issues and considerations, including certain deficiencies in the machinery for resource allocation.

The Task Force wishes to take this opportunity to acknowledge that its work could not have been accomplished so expeditiously or so well without the cooperation of many individuals and organizations from whom advice and aid was sought. Special mention should be made of the assistance of Robert R. Irwin of TRW Inc.

OCTOBER 6, 1969

# *The White House*

The President today announced another in the present series of task forces that are being established to assist the Administration with ideas and recommendations for 1970 and beyond. Ruben F. Mettler, Executive Vice President* of TRW, Inc., will be chairman of the Task Force on Science Policy. The Task Force will review the Federal Government's present science policy and make recommendations as to its future scope and direction.

The members of the Task Force on Science Policy are:

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Redondo Beach, Calif.

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*Subsequently elected President of TRW, Inc.

# *Summary of Report*

This report presents seven primary recommendations on national science policy, with more detailed recommendations to support the primary ones. The particular issues selected by the Task Force and the primary recommendations of each section are summarized below.

## Science, Technology, and National Goals

Section 1 describes the national need for excellence in science and technology, and the special contribution which science and technology can make in achieving national goals and purposes. It recommends that:

> The President explicity enunciate, as a national policy, the need for vigorous, high-quality science and technology, and call for—as one national goal—continuing leadership in science and in the technology relevant to our other national goals and purposes.

## Expanding Applications for Science and Technology

In Section 2, the Task Force suggests more effective Government leadership in mobilizing the Nation's scientific and technological capabilities to help meet the challenge of pressing social, urban, and environmental problems. Particular attention is urged to the contributions which science and technology can make to the high-priority need for improved skills in the management of programs directed toward these problems. The Task Force recommends that:

> The President direct the appropriate Departments and Agencies to strengthen their capability to utilize science and technology effectively, in a broad-scale attack on social, urban, and environmental problems.

## Management of Direct Federal Support for Basic and Applied Research

Section 3 describes the need for a better-integrated management of Federal support for basic and applied research, properly related to long-



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range projections of national interests and requirements. The Task Force recommends specific steps aimed at achieving:

> Effective and consistent commitment to long-range research
> Effective and uninterrupted support of graduate education
> Improved utilization of the Federal laboratories
> An improved process for establishing priorities in Federal support of science.

**Stimulating Technological Innovation by Private Institutions**

In Section 4, the Task Force proposed greater attention by the Federal Government to the task of stimulating private institutions to apply their scientific and technological resources to urgent social, urban, and environmental programs, particularly those not currently served effectively by already-developed market forces. Of particular importance is the conversion of these "needs" into "market opportunities" so that the Nation's largest and most effective machinery for technological innovation—business enterprise—can be harnessed more effectively to solve these pressing problems. The Task Force recommends that:

> The President enunciate a national policy of increasing long-term participation by private institutions—particularly business—in social, urban, and environmental programs. It is also recommended that the President direct the appropriate Departments and Agencies to establish broadly-based efforts systematically to identify the deterrents to private investment of capital and technology in social, urban, and environmental programs, and to suggest specific incentives for action and remedies for each such deterrent.

**Science Policy as Related to National Security**

Section 5 points out the increased importance of maintaining a strong scientific and technological capability in support of our national defense and security. As the Nation enters a profoundly new era of strategic balance with the Soviet Union, the possibility of strategic arms limitation agreements, and potentially greater penalties for technological surprise should be considered. The Task Force recommends that:

> The President enunciate a national policy of increased emphasis on research and development for national security purposes—even at the expense of current military hardware procurement, if necessary.

## International Initiatives Utilizing Science and Technology

The potential for new foreign policy initiatives utilizing our scientific and technological capabilities, and for improving the effectiveness of our international cooperation and foreign assistance programs through better use of our scientific and technological resources is discussed in Section 6. The Task Force recommends that:

> The President continue to encourage the major Departments and Agencies to suggest specific new science-based foreign policy initiatives and opportunities for international cooperation. It is also recommended that the Administration make clear a policy of technical assistance, with increased emphasis on providing assistance to under-developed nations which will help them build their own institutions of scientific research, education, and technical training.

## Continuing Development of Science Policy

Finally, in Section 6, the Task Force discusses the background and need for a continuing effort in the development of national science policy on a long-range basis, and recommends that:

> The President direct his Science Adviser to develop, for the President's approval, a broadly-based program for the continuing development of national science policy.

# *Detailed Recommendations*

**Science, Technology, and National Goals**

The Task Force recommends that the President explicitly enunciate, as a national policy, the need for vigorous, high-quality science and technology, focusing on our national goals and purposes, and recognizing the cultural and inspirational values in man's scientific progress.

The Task Force also recommends that the President call for—as one national goal—continuing leadership in science and in the technology relevant to our other national goals and purposes.

Finally, it is recommended that the President direct that increasing emphasis be given to using our scientific and technological capabilities to *quantitatively* develop and project long-range requirements in support of our national goals.

**Expanding Applications for Science and Technology**

The Task Force recommends that the President direct the appropriate Departments and Agencies to strengthen their capability to utilize science and technology effectively in a broad-scale attack on social, urban, and environmental problems. More specifically, the Task Force recommends that:

1. Each Executive Department and Agency responsible for a significant portion of the total national social, urban, and environmental programs be directed to develop (on a periodically updated basis, tied to the budget cycle), a ten- to fifteen-year projection of specific steps toward achievement of their principal goals. These projections should include sufficient quantitative detail, including costs and schedules of results to be achieved by particular points in time, to permit integrated review for adequacy and consistency by the Council on Urban Affairs and the Council on Environmental Quality. These reviews should ultimately lead to Presidential approval, and where needed, Congressional authorization. It is recommended that these Councils be supported by sufficient staff, on an ad hoc basis if necessary, to help define the initial task and to monitor its implementation.

2. In preparing these proposed long-range programs (which the Task Force recognizes, have already been initiated by some Agencies), particular attention be given to identifying long-range requirements for basic and applied research and the institutional machinery for its achievement. This should include identification of opportunities for the utilization of existing but under exploited technology, and for the identification of technical and economic issues which must be analyzed and resolved to permit timely downstream decision making. Additionally, attention should be given to the development of statements of requirements that will, when approved, permit universities, business, labor, professional, and other institutions to gain understanding of long-range national needs and planning factors pertinent to their separate functions.
3. As part of this general effort, the Office of Science and Technology should strengthen its own resources in the social and behavioral sciences, and should work jointly with the appropriate mission agencies and with the National Science Foundation to develop specific programs for enlarged support and increased utilization of the social and behavioral sciences.
4. The Office of Science and Technology should be directed by Executive Order to develop a Federal structure for technology assessment, in general accord with the recent National Academy of Sciences and National Academy of Engineering reports to the Congress on this subject. Such development should be carried out in close coordination with the Congress and the National Science Foundation, and in consultation with the NAS and the NAE.

**Management of Direct Federal Support for Basic and Applied Research**

The Task Force recommends that the President direct the Office of Science and Technology, in coordination with the Bureau of the Budget, and with the advice and cooperation of the Executive Departments and the National Science Foundation, to develop improved machinery for the integrated management of direct Federal support of basic and applied research. This effort should be related properly to long-range projections of total national interests and requirements, and should include Congressional approval as needed. To accomplish this general intent, the Task Force recommends that:

1. The level of support provided to the National Science Foundation and other basic research agencies (e.g., the National Institutes of Health) be increased as rapidly as feasible. A level of support of approximately 0.1 percent of the gross national product (GNP) is suggested as a reasonable level for support of the National Science Foundation, to be achieved as soon as possible.

The level of support should permit the NSF to be responsible for approximately one-third of all Federally supported basic and academic research. A transition phase extending over several years may be necessary to insure continuing support (without reductions in total levels) of projects and facilities which should be supported nationally and phased out of mission agencies. Great care must be exercised to maintain close connection between each mission agency and basic research in areas which can reasonably be expected to bear strongly on that agency's problems. This would mean continuing support of considerable basic research by mission oriented agencies and avoiding too narrow an interpretation of the relevance of such research.

2. A specific program be developed and proposed to the Congress in general accord with the National Science Board Report NSB 69–1 on Federal support of graduate scientific education. Key steps in implementing this program should receive legislative authorization and initial appropriations not later than fiscal year 1972.
3. A review be made of the role and future plans of all Federal laboratories be carried out by a commission made up primarily of persons outside the sponsoring agencies, and possibly organized through the cooperative efforts of the President and the Congress.
4. The Office of Science and Technology be designated by Executive Order as the principal organization within the Executive Branch for establishing the priorities among the various competing scientific research programs and major projects which will be considered in developing the Federal budget to be recommended to the Congress, beginning in fiscal year 1972. In accomplishing this task, the OST, in close coordination with the Bureau of the Budget, should receive the advice and cooperation of the Executive Departments and the National Science Foundation, and should seek advice from outside the Government, including the National Academy of Sciences and the National Academy of Engineering.

**Stimulating Technological Innovation by Private Institutions**

The Task Force recommends that the President enunciate a national policy of increasing long-term participation by private institutions—particularly business—in social, urban, and environmental programs.

It is also recommended that the President direct the appropriate Departments and Agencies of Government to establish broadly-based efforts systematically to identify the deterrents to private investment of capital and technology in social, urban, and environmental programs, and to suggest specific incentives for action and remedies for each such deterrent.

## Science Policy as Related to National Security

The Task Force recommends that the President enunciate a national policy of increased emphasis on research and development for national security purposes—even at the expense of current military hardware procurement, if necessary.

## International Initiatives Utilizing Science and Technology

The Task Force recommends that the President continue to encourage the major Departments and Agencies of Government to suggest specific new science-based foreign policy initiatives and opportunities for international cooperation.

It is also recommended that the Administration make clear a policy of technical assistance, with increased emphasis on providing assistance to under-developed nations, which will help them build their own institutions of scientific research, education, and technical training.

## Continuing Development of Science Policy

The Task Force recommends that the President direct his Science Adviser to develop, for the President's approval, a broadly-based program for the continuing development of national science policy. This program should provide for full participation by individuals from both within the Government and from outside the Government, experienced in politics, economics, management, labor, and engineering, as well as practicing scientists and science administrators.

# *Science, Technology and National Goals*

This section will discuss briefly the national need for science and technology, the problem of defining long-range goals in quantitative terms, and the importance of science and technology to economic growth.

## The National Need for Science and Technology

Our national progress will become ever more critically dependent upon the excellence of our science and technology. A vigorous, high-quality program aimed at advancing our scientific and technological capabilities (including the social, economic, and behavioral components) is vital to all national goals and purposes. Such a program is especially vital to our national defense and security and to our international posture generally; to our ability to negotiate properly safeguarded arms limitations; to our continued economic growth and development and to our international trade balance; to the health of business, labor, and the professions; to the quality of our environment; to the personal health and welfare of all; to the scope and quality of our educational processes; and to the culture, spirit, and inspiration of our people generally. The effectiveness of essentially all our social institutions, including particularly Government itself, is deeply influenced by the quality of our science and technology.

The Nation, therefore, has a fundamental need for excellence in science and technology. Accordingly, it also needs to insure that the effectiveness of our science and technology is not downgraded or destroyed by the unthinking or the uniformed. That is not to say that the limitations of science and technology should not be recognized. We do not suggest complacent acceptance of the unwanted side effects of narrowly motivated or incompletely understood applications of science. Nor do we suggest that technology should dictate social purpose. On the contrary, we wish to emphasize the importance of seeking to optimize utilization of science and technology in the service of social, political, and economic goals.

*Anti-Science Attitudes.* The rapid rise of attitudes disdainful of science and technology, and the disillusionment of many young people with

science and technology is of grave concern. The sources of these attitudes include deficiencies in the application of science and technology which should in fact be criticized and should be corrected. Inanimate technology is not of itself the problem; rather the primary need is "to conceive ways to discover and repair the deficiencies in the processes and institutions by which society puts the tools of science and technology to work." (1) The sources of the shift in attitudes toward science and technology also include widespread lack of perspective and understanding of their nature and role in past and future improvement in the human condition. The public and its elected representative must have a better grasp of both the limitations and the promise of science and technology. Priority should be given to presenting this complex matter to the public in a balanced and understandable fashion. The responsibility for achieving this understanding starts with the Executive and Legislative branches of the Federal government and spreads to include state and local government, universities, business and professional organizations, and other private institutions in positions of leadership.

*Scientific Leadership.* The scientific and technological resources of this Nation are among its most powerful tools for the achievement of our social, political, and economic purposes. The management, strength, and proper allocation of these vital resources are political responsibilities of the highest significance, with not only short-term but also very long-term implications both nationally and internationally. The leadership of today must provide the legacy for tomorrow.

The Task Force believes that one of the important national goals for which this Nation should strive is leadership and excellence in science itself—as a long-range investment in achieving the Nation's other goals, as a precursor to more directly applicable and controllable technology, and as a contribution to the culture, spirit, and inspiration of our people.

## Defining Long Range National Goals and Issues in Quantitative Terms

National policy governing science and technology should in principle be a mirror image of our national goals and purposes. Science policy should in part be a statement about the priorities of the future. While these generalized statements have wide acceptance, many of the mechanisms and concepts implicit in them are difficult to define in detail and complex to administer.

*Regional Goals.* The machinery of Federal, state, and local government is vast. Each major problem, such as environmental pollution, is pervasive and interdependent with others. Hundreds of separate institu-

tions, both private and public, must function as a part of a team if the problems are to be solved. Proper distinctions must be made between the responsibilities and opportunities of Federal, state, and local government, as well as between those of universities, business enterprise, and other private institutions. National goals and purposes have distributed (e.g., geographical) as well as central components. The "points of principal action"—and hence the foci of primary responsibility and opportunity for solution—of some of our most urgent national concerns are central (e.g., national defense). Others are regional (e.g., air and water pollution, interurban transportation), while still others can best be managed at the state or city level.

*Definition of Goals.* The central crisis is one of management, of leadership, of inspiration, with an eye to the future as well as the present. Generalized goals must be broken down into specific sub-elements and specific realistic milestones established; specific responsibilities must be assigned with clear-cut processes of review, specific attainable criteria and standards with quantitative as well as qualitative substance must be promulgated; and all of these should be projected over suitable periods of time (e.g., ten to twenty years), with specific machinery for review and reprojection.

Such long-range national programs should, of course, have the benefit of searching Congressional debate and formal legislative approval as appropriate. Frequently heard reasons why ten- or fifteen-year national programs cannot be established (e.g., the yearly budget cycle, the short-term nature of legislative and executive terms, the unwillingness to commit future administrations) are not convincing.

*The Contribution of Science and Technology.* We have been discussing one of the central responsibilities of government. The more restricted question here is: what special contribution can science and technology make to the definition and achievement of long-range national goals? Of course, basic and applied research can contribute to understanding—the vital basis for all other parts of the process—if focused properly on these problems. In addition, "technology has a direct impact on values by virtue of its capacity for creating new opportunities. By making possible what was not possible before, it offers individuals and society new options to choose from." (2) Finally, a great majority of our current urban and environmental problems have important technological or scientific components. That is not to say that science and technology alone can solve these problems or even that the technological component is normally the dominant one—in most cases, it is not.

Because of the technological components inherent in many current problems, however, and because of the nature of the tools of science and technology, they can make a special and vitally needed contribution to

the definition of long-range goals, and to the central *management* problems inherent in broad long-range national programs. Detailed quantitative development of qualitative goals—which engineers and scientists are especially equipped to do—can aid in choosing wisely among alternatives. It can also help define the subelements of a particular program with sufficient clarity to permit each of the widely dispersed elements in our society to grasp its part, and to assist in reviewing and re-projecting the program as needed.

It is the view of the Task Force that a special effort is needed to make fuller use of the tools of science and technology in *quantitatively* projecting long-range requirements associated with our many pressing social, urban, and environmental problems: air and water pollution, waste disposal, educational services, health care, mass transportation, housing and urban development, crime prevention, and energy requirements, for example. The magnitude of concern and awareness for such problems, and increasing realization of the urgent need to mobilize our resources to combat them, is clearly reflected in such recent actions as the establishment by the President of the Council on Urban Affairs and the Council on Environmental Quality.

> "We can no longer afford to approach the longer-range future haphazardly. As the pace of change accelerates, the process of change becomes more complex. . . . Our need now is to seize on the future as the key dimension in our decisions, and to chart that future as consciously as we are accustomed to charting the past."
>
> —RICHARD M. NIXON, *July 12, 1969.*

## The Importance of Science and Technology to Economic Growth

Economic growth will, over a long period of time, define the total level of resources within which our national goals must be achieved. Because of the central significance of economic growth to all other national goals, it is especially important to point out its dependence on science and technology.

It is generally recognized that the economic growth of highly industrialized countries in the western world has been heavily dependent on the technological developments which have been incorporated into their societies. In the past half century the economic growth of the United States has been as much determined by new technology as it has by the continuous investment of capital. If a major national goal is increasing the quality of life for the mass of our population, it becomes essential that continued technological development also be a high priority national goal. A stagnant technology will mean a stagnant economy. In this regard, it

is of interest to note the statement of Mr. Kosygin to the XXIII Party Congress in March 1966:

> ". . . The course of the economic competition between the two world systems depends on the rate of development of our science, and on the scale on which we use the results of research in production . . ."

The growth and diffusion of technology have expanded the goods and services available to the people by improving the inputs used for production, by improving the outputs flowing from the production line, and by reducing the volume of inputs needed per unit of output. Scientific and technological advances have led to the invention or discovery of new and improved materials, or materials that can substitute for limited or vanishing natural supplies. The quality of machines, plant, and rolling stock has been improved and their ability to deliver output at less cost greatly enhanced. New or better final products have been turned out. Better production processes and better organization of the flow of materials and of production have cut costs. Better control has made for economies in the use of inventories. People have been encouraged to improve their produtive capacity and to engage in economically productive work by the attraction of the new products made available for consumption by technological advance.

However, technological change also leads to regional shifts in the distribution of resources, the obsolescence of skills, etc., which require movement, retraining, and other adjustments by people. Such change puts a high premium on those who are current in scientific and technical skills, and on continued education of personnel already in responsible jobs. The costs entailed in all of these adjustments should, of course, be deducted in assessing the contribution of science and technology to the growth of output. Although difficult to measure, some place these costs very high, even to the point of questioning the social value of any significant degree of technological change. Most economists believe, however, that a reasonable allowance for such costs does, on the whole, leave a substantial net gain.

Continued study of the role and potential of science and technology in promoting and enhancing economic growth—both nationally and regionally—is important to the setting of realistic long-range quantitative national goals.

**Recommendations**

The Task Force recommends that the President explicitly enunciate, as a national policy, the need for vigorous, high-quality science and tech-

nology, focusing on our national goals and purposes, and recognizing the cultural and inspirational values in man's scientific progress.

The Task Force also recommends that the President call for—as one national goal—continuing leadership in science and in the technology relevant to our other national goals and purposes.

Finally, it is recommended that the President direct that increasing emphasis be given to using our scientific and technological capabilities quantitatively to develop and project long-range requirements in support of our national goals.

# *Expanding Applications for Science and Technology*

This section discusses the new challenges facing science and technology, the need to achieve fuller use of existing technology, the need to strengthen the contribution of the social and behavioral sciences, and the need for a Federal capability to assess technology.

## New Challenges

This is a time of challenge and crisis for science and technology. Pressing social and environmental problems with significant scientific and technological components are evident on all sides—air and water pollution, waste disposal, educational services, health care delivery, mass transportation, land use, housing and urban development, crime prevention, and of course the revenue and funding structures for all of these. At the same time,

> This is a time of awareness that science and technology are changing our civilization rapidly and that in these developments of man lie potential powers even greater than those that have already so profoundly influenced his way of life. It is also a time when the typical citizen is anxious to see something done about a growing list of serious shortcomings of society. It is not surprising, then, that the thinking man today tends to connect the potency he understands the scientific approach to possess with the need he feels for a superior attack on our unsolved problems. Why do we not, he asks, make full application of science and technology to seek corrections of ills? (3)

Naturally, scientist and engineers and their institutions wish to respond. They see the scientific and technological components of these problems (including particularly the behavioral components), they see the interacting "systems" nature of most of them and hence see applications for newly-developed systems analysis and management skills, but they also recognize that in most cases the scientific or technological components are not the dominant ones. Stubborn and difficult political and

economic issues, management complexities, social attitudes, and sluggish institutions (including many internal to science and engineering) seem to block the application of their skills to the urgent problems. Past successes in making significant contributions to major and highly visible national problems such as defense, atomic energy, space, communications, agriculture, highway and air transportation, and electric power, provide only a few guidelines for the newer problems. The older ones, despite their highly sophisticated scientific and technological components, begin to look very much easier than the new. Dominating the new problems is the high levels of skill required in management of the processes of change. A mismatch has arisen between the problems of our society and the apparatus available to attack them.

While pondering this dilemma regarding the application of the tools of science and technology, scientists and engineers and their institutions find themselves under attack, to their surprise and dismay. The apparent impotence of science in avoiding or solving these social problems leads many to say that "science is no longer relevant." Particularly, science seems less than relevant to the unemployed, the hungry, the blacks, and the young. Confusion and misunderstanding between science and technology, per se, and the institutions which employ these tools results in some attacks. Thus, to some, science is responsible for the Vietnam war or the arms race. To others, technology appears out of control, and unwanted side effects of unwise or incompletely understood applications of technology obscure the history of the contributions of science and technology to the improvement of the human condition. Perhaps more serious is a belief by some that the scientific establishment is deaf to the moral, social, political, and ethical consequences of research.

The dual challenge of expanding the application of the tools of science and technology to broader problems, and of understanding and responding to a rise of anti-science and anti-technology attitudes brings into sharp focus new requirements in science policy.

The Task Force believes that finding workable ways of bringing the full weight and power of science and technology to bear on the current social, urban, and environmental problems, in proper context and proper harmony with related components of the total problem, is a matter of the highest urgency. This must be done without detracting from the support urgently required on a continuing basis by our national security programs. Particular attention is required to the development of those contributions which science and technology can make to the high priority need for improved skills in the management of programs directed toward these problems.

## The Need to Achieve Fuller Use of Existing Technology

Closely related to the previous discussion is the problem of already developed, but under exploited, technology which could make significant contributions to the solution of our pressing urban and environmental problems if properly applied. Continuing research and development are needed on many aspects of these problems, but there are also many aspects for which the technology is at hand.

As stated in a recent report of the Harvard University Program on Technology and Society:

> Failure of society to respond to the opportunities created by new technology means that much actual or potential technology lies fallow, i.e., is not used at all or is not used to its full capacity. This can mean that potentially solvable problems are left unsolved and potentially achievable goals unachieved, because we waste our technological resources or use them inefficiently. A society has at least as much at stake in the efficient untilization of technology as in that of its natural or human resources. . . . But there are also cases where technology lies fallow because existing social structures are inadequate to exploit the opportunities it offers. (2)

We are beginning to make some progress in correcting this condition, of course. The Harvard report goes on to observe: "Government in general and agencies of public information in particular are not yet equipped for the massive task of public education that is needed if our society is to make full use of its technological potential, although the federal government has been making significant strides in this direction in recent years. Thus, much potentially valuable technology goes unused because the public at large is insufficiently informed about the possibilities and their costs to provide support for appropriate political action."

*The Health Care Crisis.* A typical current example of the under exploitation of available technology can be found in the field of health care. Here, as in a number of other fields (e.g., education, air pollution, and water pollution), the problem relates as much or more to our institutional and social restraints and to political and economic barriers than to the simple acquisition and employment of the applicable technology.

In the increasingly critical case of health care, there are very large numbers of people within the United States, particularly in the disadvantaged areas of our cities and in many rural regions, who receive little or no medical care. Not only do we need more physicians, but we must also define and educate other kinds of health care personnel whose efforts can complement those of the physician and bring quality medical care to every individual, regardless of his financial status or location.

In our health care delivery system (or, as some would describe it, non-system), we are able to carry out sophisticated and dramatic forms of therapy in our best university medical centers, but the costs for medical care are rising at such a phenomenal rate that the benefits of such advanced research and scientific achievement are all but unavailable to the vast majority of those who would be most helped by such advanced techniques. The advent of sophisticated technology has at once promised great benefits in terms of medical care, but at the same time greatly increased the costs of such care. We have failed to devote sufficient resources to defining the ways in which existing technology can improve health care and at the same time help control its cost. A significant ongoing investment in this area is essential, as part of a policy directed towards orderly solutions and long-term progress.

**Strengthening the Contribution of the Social and Behavioral Sciences**

National science policy must consider current trends in our society such as the exponentially changing social, cultural, political, and economic environment which calls for improvement in our institutions to enable them to adapt responsively; the growing difficulty of retaining individual identity and integrity in the face of increasingly complex institutions; the growing alienation of deprived segments of our population and of much of youth to our existing values and institutions; increasing demands for more active participation of all institutions in social, cultural, and political programs designed to improve the quality of American life; and accelerating technological changes which require the development of a scientific humanism—a world view of the social and humanistic implications of advancing technology. Considering these trends in our society, it is clear that the social and behavioral sciences have a significant role to play in coping with our socio/technological problems.

The tie between basic science and our current social problems can be reinforced in two ways: by identifying the technological components of the social problems and then supporting the basic science underlying these technologies; and also by strengthening the basic *social* sciences that underpin our understanding and control of social processes. Both of these strategies lead to emphasizing the scientific-technological parts of the Government agencies having responsibility for dealing directly with our social problems, and both emphasize the necessity for closer working relationships between social and physical scientists, and among engineers, managers, and applied social scientists. Special efforts are needed to force this merger of talents.

*Recent Studies.* Two recent studies by distinguished national groups (4, 5), which examine the role of the social and behavioral sciences in programs directed towards major national problems, recommend that Federal science policy give increased attention to the further development and improved utilization of the social and behavioral sciences. The Task Force supports this general view.

These reports suggest a number of specific steps which the Task Force believes should be considered carefully in the development of a specific program. The steps suggested include the following:

- Provision of substantial financial and intellectual support for efforts now underway to develop a system of social indicators.
- Investigation of the procedural and technical problems involved in devising a national data system for scientific purposes, designed to provide useful data while still protecting individual and institutional privacy.
- Consideration of the feasibility of establishing broadly-based university training and research programs in the form of graduate schools of applied behavioral science under administrative arrangements that lie outside the established disciplines.
- Increased Federal support of basic and applied research in the behavioral and social sciences to sustain the normal growth of the research enterprise at a healthy rate over the next decade.
- Appropriation of sufficient Federal funds to support the establishment of social problem research groups or institutes; such support to increase gradually in subsequent years as such groups mature.

*Development of Specific Programs.* The Federal Government should assume leadership in strengthening the contribution of the social and behavioral sciences to the solution of our pressing social, urban, and environmental problems. A first step in this direction could be for the Office of Science and Technology and the National Science Foundation to develop specific programs for enlarged support and increased utilization of the social and behavioral sciences in the directions suggested by the two studies mentioned above. Of course, the Task Force recognizes that there are a number of existing efforts already underway aimed at achieving many of these same objectives, and these existing efforts should be encouraged. The development of specific programs should give special weight to the following:

1. The need for direct on-the-scene involvement by social and behavioral scientists in practical real-life situations, properly linked to the political and decision-making processes, particularly at the local level. Special attention should be given to on-the-job fellowships for graduate students, and for young people from industry, labor, and the Federal agencies, to develop trained candidates for the very difficult urban management tasks.

2. The need for greater direct involvement of engineering and technical personnel in interdisciplinary training and multidisciplinary projects involving the social and behavioral sciences, at both undergraduate and graduate levels.
3. The need for wide participation by industry, labor, and the professions generally in the special social problem research groups and university training and research programs referred to in Citations 4 and 5.

## Achieving More Effective Assessment of Technology

Additional machinery for technology assessment is needed, and the basis for developing such machinery now exists.

Two recent reports, one by the National Academy of Sciences and one by the National Academy of Engineering, both prepared at the request of the House Subcommittee on Science, Research, and Development, have analyzed the concepts and methods of technology assessment. Recent Congressional consideration of this matter took place in both the 89th and 90th Congresses. H.R. 6698, introduced by Congressman Daddario, proposed a Technology Assessment Board as a means of identifying, assessing, publicizing, and dealing with the implications and effects of applied research and technology. Senate Resolution 68, introduced by Senator Muskie, proposed the establishment of a Select Senate Committee on Technology and the Human Environment. Recent hearings conducted by the House Subcommittee on Science, Research, and Development have updated and further examined technology assessment.

The NAS study (1) says, "In recent years concern has mounted over society's seeming inability to channel technological developments in directions that sufficiently respect the broad range of human needs. Whether rightly or wrongly, the belief is now widely held that the continuation of certain technological trends would pose grave dangers for the future of man and indeed that the ill-considered exploitation of technology has already contributed to some of the most urgent of our contemporary problems. . . . Even among those who readily concede that technological advance has, on the whole, been a great boon to mankind, there has emerged a deep strain of skepticism toward proposals and projects that, in an earlier day, might have been hailed as the very symbols of human progress."

The report continues that the choice is "between technological advance that proceeds without adequate consideration of its consequences and technological change that is influenced by a deeper concern for the interaction between man's tools and the human environment in which they do their work."

The NAE study (6) concludes that technology assessment can be expected to perform important roles by:

1. Clarifying the nature of existing social problems as they are influenced by technology, possibly with indications of legislation needed to achieve satisfactory control.
2. Providing insights into future problems, to make possible the establishment of long-term priorities and to provide guidance for the allocation of national resources.
3. Stimulating the private and public sectors of our society to take those courses of action for the development of new technology that are most socially desirable.
4. Educating the public and the government about the short-term and long-term effects of the range of alternative solutions to current problems.

The Task Force generally concurs with the concepts and methods suggested by the NAS and NAE studies, and supports their general conclusions. In its final summary, the NAS report states:

> Our study has revealed that existing mechanisms, whether they involve government agencies, private industries, or professional groups, possess intrinsic limitations, some structural and others psychological, that leave serious gaps in the spectrum of processes that assess and direct the development of technology in our society: In the formulation of issues for assessment and in the attribution of value to alternative outcomes, those processes too often ignore the broader social and environmental contexts in which their effects are felt. In the calculation of costs and benefits, they ascribe too little significance to the preservation of future options. They give too little attention and support to research and monitoring programs calculated to minimize technological surprise and to deal more rationally with the burdens of uncertainty. They frequently reflect the views, interests, enthusiasms, and biases of unduly narrow constituencies and create insufficient opportunities for meaningful public participation in choices having major public consequences. And they manifest too little concern for the evolution of consistent principles in the formulation and enforcement of assessment criteria.
>
> The reasons for these shortcomings are complex and varied. In part, the difficulties are conceptual—inadequacies in analytic tools and in theoretical understanding; failures of imagination; deficiencies of data; the sheer technical difficulties of perceptive and precise evaluation. In greater measure, the problems are institutional—economic, legal, or political constraints upon the interests that each individual decision-maker is encouraged to treat as his own; limits upon the representation of varied interests in collective processes of decision; constraints upon the coordination and focusing of pertinent efforts. These difficulties cannot be overcome at a single

stroke; but they can gradually be reduced by a program of technology assessment that is broader in fundamental conception and scope than any now existing, one that takes into account the changing values, sensitivities, and priorities of society.

The present organization of private and public assessment systems is too fragmented and uncoordinated, too lacking in professionalism, continuity, and detachment, to provide a viable institutional basis for the support of the research and education that a sufficiently broad technology-assessment program will demand and for the development of the professional competence and vision that such a program will require. No institution or group of institutions is today charged with the responsibility, or equipped with the resources, to review the criteria and assumptions, monitor the operating procedures, and integrate the findings, of our many technology-assessment efforts—even those undertaken within the federal government—or to stimulate the development of a set of coherent principles that might increase the quality and influence of such efforts and enhance their sophistication.

Although we recommend the creation of new institutions in the federal government to perform these integrating functions of review and stimulation, we acknowledge that the present multiplicity of technology-assessment processes is both desirable and necessary. Technological development pervades so many aspects of contemporary life that no limited number of organizations devoted to technology assessment could competently span the enormous range of relevant activities. Thus we do not contemplate in this report or foresee in the future a highly centralized process of technological evaluation, even for the areas of technology that are largely dependent upon federal programs and policies. Such centralization would be not only unworkable but unwise, politically unacceptable, and extremely dangerous. Thus new institutions are needed not to supersede existing mechanisms but to supplement them (1).

A Federal technology assessment structure should have components located strategically in both the Executive and the Legislative branches to create a forum for responsible technology assessment activities not only in Government but also in the private sector. The organizational units engaged in technology assessment should not also be responsible for decision-making on specific programs. They should be strictly advisory in nature.

As defined by the NAS study (1), the initial activities and areas of concern for technology assessment organizations should include the following:

1. Undertaking substantial in-house studies to evaluate trends in technology and in technology assessment practices; to examine the operations of existing assessment mechanisms; to establish priorities

for technology-assessment efforts; and to derive policy alternatives and recommendations from research.
2. Supporting major research activities in external organizations with respect to technical issues arising in the course of specific assessments and theoretical issues pertinent to the improvement of the intellectual base for technology assessment in general.
3. Encouraging activities and programs related to the stimulation of public awareness of, and interest in, assessment issues and the education and development of professional groups with broadened perspectives to staff future technology-assessment activities in industry, in government, and in other institutions.

**Recommendations**

The Task Force recommends that the President direct the appropriate Departments and Agencies to strengthen their capability to utilize science and technology effectively in a broad-scale attack on social, urban, and environmental problems. More specifically, the Task Force recommends that:

1. Each Executive Department and Agency responsible for a significant portion of the total national social, urban, and environmental programs be directed to develop (on a periodically updated basis, tied to the budget cycle), a ten- to fifteen-year projection of specific steps toward achievement of their principal goals. These projections should include sufficient quantitative detail, including costs and schedules of results to be achieved by particular points in time, to permit integrated review for adequacy and consistency by the Council on Urban Affairs and the Council on Environmental Quality. These reviews should ultimately lead to Presidential approval, and where needed, Congressional authorization. It is recommended that these Councils be supported by sufficient staff, on an ad hoc basis if necessary, to help define the initial task and to monitor its implementation.
2. In preparing these proposed long-range programs (which, the Task Force recognizes, have already been initiated by some Agencies), particular attention be given to identifying long-range requirements for basic and applied research, and the institutional machinery for its achievement. This should include identification of opportunities for the utilization of existing but under exploited technology, and for the identification of technical and economic issues which must be analyzed and resolved to permit timely downstream decision making. Additionally, attention should be given to the development of statements of requirements that will, when approved, permit universities, business, labor, professional, and other institutions to gain understanding of long-range national needs and planning factors pertinent to their separate functions.

3. As part of this general effort, the Office of Science and Technology should strengthen its own resources in the social and behavioral sciences, and should work jointly with the appropriate mission agencies and with the National Science Foundation to develop specific programs for enlarged support and increased utilization of the social and behavioral sciences.
4. The Office of Science and Technology should be directed by Executive Order to develop a Federal structure for technology assessment, in general accord with the recent National Academy of Sciences (1) and National Academy of Engineering (6) reports to the Congress on this subject. Such development should be carried out in close coordination with the Congress and the National Science Foundation, and in consultation with the NAS and the NAE.

# *Management of Direct Federal Support For Basic and Applied Research*

## Background of the Current Problem

The National Science Foundation was created in 1950. Also by 1950, mission-oriented Federal agencies such as the Department of Defense, Office of Naval Research, National Institutes of Health, and the Atomic Energy Commission were developing programs in support of broad areas of basic and applied science and graduate education. Never planned as such, and without explicit statement of policy, the Federal Government became the principal patron of all branches of science, operating in-house laboratories, supporting large national laboratories and facilities, and sponsoring research through programs managed by a dozen agencies, each making its own case, with variable success, before its own cognizant committees of the Congress. The result, taken as a whole, was a rapid growth in basic and applied research, responsive to the needs of the Nation.

*Decrease in Support Levels.* As long as total funds continued to grow at a rapid rate, the weaknesses in the unintegrated management of Federal support for research and graduate education were not forced into view. As total Federal funds for science leveled off however, a number of problems emerged which are becoming increasingly apparent today:

1. Federal funding of science has remained approximately constant for four fiscal years; however, inflation during the same period has decreased the purchasing power of these funds, and hence the effective level of Government support has declined by nearly one-quarter.
2. Due to the momentum of previous years, science itself has become increasingly sophisticated, competent, and hence, increasingly expensive, perhaps by 5 percent per year.
3. Young men and women, earlier encouraged to embark upon careers in science, continued to emerge from the educational pipelines and, although they could find employment, found it extremely difficult to obtain employment consistent with their interests.

4. The mission agencies, with reduced research budgets and purchasing power, have abandoned areas of science that, in their judgment, would not have an impact on their immediate short-term technological needs. Examples: ONR abandonment in nuclear physics; ARPA retrenchment in material sciences; NIH withdrawal of support in chemistry and plant science. This has produced imbalances in our national scientific effort. Further pressure on mission agencies to drop other areas of research support is evident and will probably increase.
5. The NSF, whose fiscal year 1970 appropriation is less than that for fiscal year 1965, cannot assume support for even the best people—Nobel laureates—and the many programs abandoned by the mission agencies. It is not possible continually to reduce the size of individual grants without sacrificing the dynamics of work in progress; there is a critical size in manpower and funds required to make satisfactory progress.
6. Mature and productive investigators in all disciplines have found it increasingly difficult to obtain sufficient support for their research programs at a level adequate to assure progress in the laboratory; the resultant decline in morale has become serious.
7. Universities find themselves responsible for obligations incurred in good faith in the expectation of continued Federal funding. Moreover, while this is happening, virtually all institutions of higher learning are being confronted with growing deficits as their traditional sources of income fail to keep pace with rising enrollments and costs.
8. A number of Federal laboratories, some of which were created or expanded rapidly, now face retrenchment and uncertainty of mission.

In the face of this general crisis, demands for funds in support of science have nevertheless been sharply increasing. Certain geographic areas of the Nation, encouraged by the Administration and the Congressional leadership of both parties, have been engaged in upgrading their scientific capabilities. This enterprise has been aided by the Science Development Award Programs of the National Science Foundation, their equivalents at the National Institutes of Health, and by ARPA's Project Themis in the Department of Defense.

*Basic Research Sponsored by Mission Agencies.* Special attention needs to be given to a present trend, as embodied in Section 203 of the fiscal year 1970 Military Procurement Authorization Bill, of Congressional and public pressure to narrow the scope of research supported by the mission-oriented agencies. As stated by this section, the Defense Department may not support "any research project or study unless such project or study has a direct and apparent relationship to a specific military function." The statement in itself is not unreasonable. What is unreasonable and will be

damaging, however, is the apparent thought that under such a regulation the Defense Department should drop much of the presently supported basic research. Mission oriented Governmental agencies do and should support much long-range basic research, information from which is calculated to have a direct bearing on some aspect of their mission. It would be a great mistake for the Defense Department to avoid the bolder or imaginative and longer-range research efforts because of a myopic interpretation of their bearing on its problems. All mission oriented agencies need to be in close contact with the best and most advanced research which can apply to their problems. This contact is important both to them in taking advantage of the latest scientific developments, and to the stimulation and vigor of basic research itself through adequate contact with applied problems.

The close and multiple contacts back and forth between basic research, applied research, and applications themselves, and among Governmental, university, and industrial groups which the United States has achieved is the envy of most other nations. The philosophy on which these contacts have been made and maintained seems now to have been forgotten as various forces inside and outside of Government seem intent on dismembering our present very effective system.

The subject of research support by both the National Science Foundation and the mission agencies was covered explicitly in Executive Order 10521 (7), issued by President Eisenhower in 1954. Its content is still applicable to our current situation.

Meanwhile, the development of the natural sciences themselves proceeds apace, offering almost innumerable exciting opportunities for important new starts on the scientific frontiers—starts requiring the large sums needed to fund, for example, various new forms of radio telescopes, optical telescopes, high energy accelerators, ocean-going vessels, instrumented satellites, and the next generation of instrumentation of small science such as mass spectrometers, ultra-centrifuges, NMR spectrometers, high voltage and flying spot electron microscopes, and, increasingly, funds to defray the costs of computer usage. Almost all of these have already been deferred for several years.

## More Effective Commitment to Long Range Research

Much of the basic research of the highest intellectual merit and interest will always be too remote to be joined currently to technology or to the human problems it can ultimately help to solve. Much of this component of research has, in the long run, its ultimate home in the National Science Foundation. Whether or not this segment of science remains strong in

the United States is therefore dependent to a great degree on the level of support provided the NSF. The time has come for a more effective commitment to long range research. The National Science Foundation should truly become the lead agency in this regard. The same commitment to long range research should apply to organizations such as the National Institutes of Health.

Dr. Lee A. DuBridge, Director of the Office of Science and Technology, recently expressed similar views in his testimony of July 10, 1969 before the Subcommittee on Science, Research, and Development of the House Committee on Science and Astronautics. In discussing the National Science Foundation since its creation in 1950, Dr. DuBridge stressed that the NSF has been instrumental in providing support to many areas of science that were not under the purview of the mission agencies, or only very partially so. The National Science Foundation has also made significant contributions to the progress of graduate education in the sciences and to the improvement of science education in the colleges and high schools. In spite of this, Dr. DuBridge pointed out, many today feel that our Federal science structure is inadequate, partially at least because the vision of those who were responsible for the creation of the NSF has never been adequately conveyed to the Congress and the people of this country. Support of the National Science Foundation has not been at a level consistent with its originally-stated goal of providing an independent agency of Government whose sole mission and function is the health and welfare of the Nation's total scientific enterprise.

The appropriation to the NSF for fiscal year 1970 will be on the order of $35–45 million less than for fiscal year 1965. Meanwhile, there is Congressional concern with the device of funding support for fundamental science or graduate education through the mission agencies. As opportunity for growth in the funding of science resumes, the Task Force believes that disproportionately increased incremental appropriations should be made available to the National Science Foundation. This agency, which now provides one-eighth of all Federal support of fundamental research and one-sixth of Federal support of academic research, should be brought as rapidly as possible to about one-third of the Federal totals.

Since the need for the results of fundamental and academic research will continue to increase as our national economy grows (and with it increasing demands from such problem areas as urban and environmental decay, demands for health care, and increasing needs for education) it is the suggestion of the Task Force that the level of Federal support for basic science through such agencies as the NSF, NIH, and other agencies should be tied to our Gross National Product, so that as

our GNP grows, the concomitant support of fundamental and academic research will also grow. Without such growing support for basic science, the GNP itself will suffer, and economic growth will slow down.

## Federal Support to Graduate Education

The totality of research in the United States, and its objectives and principal motivation, can be roughly categorized in the following fashion:

1. The development for commercial purposes of new industrial products. This is usually performed in industrial research laboratories and is motivated by the objective of meeting or developing consumer or industrial use.
2. Government mission oriented research to meet the near-term objectives of our national security, national space program, and such national resource programs as energy, water, transportation, and communication.
3. Research at the universities for the dual objectives of developing new knowledge and the education of advanced scientific and engineering talent.

If these three categories are considered in terms of their need for Federal support, the evaluation is quite different for all three. In the case of commercially oriented industrial research, the direct relationship between the growth and market potential of each specific industry will determine the investment in basic and applied research and provides its own stimulation and an internally consistent rationale which will promote the health of our industrial efforts. In a similar fashion, the Government mission oriented developments will be determined as matters of national policy in relation to specific goals and the importance of these goals. However, the third category, university research, does not have this simple relationship between immediate objectives and research investment, and therefore requires careful development of a philosophy and plan for Government support.

The university graduate schools of science and engineering are the key to providing for our national needs in science and technology in two important ways. First, they provide the basic structure for the accomplishment of much basic research and new scientific observations. Secondly, they generate a flow of trained and educated scientists and engineers who enter our industrial and Federal research laboratories, where they translate these new results into tangible applications and products. Some of them remain in the university environment to continue the process of research and scientific education.

At present, our university graduate schools are faced with many serious problems, due largely to the manner in which Federal agencies have

recently been forced to handle their funds for research grants and contracts. The graduate schools face fluctuations both in levels of support and the continuity of such support, to the extent that it is becoming nearly impossible for these institutions to carry out in any reasonable manner their long-range planning. A number of excellent studies and analyses of this situation are available, and it is widely agreed that what is needed is not so much just more money, but rather a consistent long-term Federal policy toward graduate education allowing universities to make rational plans for the future.

U.S. universities currently depend on Federal research support for approximately 30 percent of their total income from all sources. The greatest part of this support is provided in the form of individual research grants awarded in response to specific research proposals. The grant is awarded by a Federal agency, typically, in order that it may benefit from the results to further its basic mission. Inherent in the process has been the fact that the grant provides at least some support for the education of graduate students who participate in the research project, and also carries much of the overhead costs associated with that particular project.

The Task Force believes that the most careful consideration should be given to the recent studies of graduate education conducted by the National Science Board (8, 9). It believes that this pressing issue has been thoroughly and adequately analyzed and examined, and that sufficient data are now at hand to permit the Federal Government to take effective policy action. The Task Force concurs in the following proposed expression of national policy, as presented in National Science Board Report 69–1 (8):

> It is the policy of the United States that the Federal Government, in cooperation with State governments and all other participating institutions, shall encourage and financially support the conditions essential to graduate education: the fruitful and mutually strengthening associations of student and teacher, of research and instruction, and of the graduate institution and society. It is in the national interest that there shall be colleges and universities in all regions of the Nation that maintain programs of high quality in graduate education, dedicated to creative inquiry in the arts and humanities and in the social and natural sciences and engineering, to the transmission of high standards of research, scholarship, and professional service to succeeding generations, and to the use of such knowledge and understanding for the benefit of mankind.

The National Science Board report continues with a recommendation that the Federal Government should accept a continuing responsibility for a significant share of the total support of graduate education, administered to supplement and encourage support by non-Federal sources, both

public and private. Federal support should also be administered to protect the autonomy and integrity of educational institutions by supporting graduate education and academic research in the sciences and engineering as closely related processes.

The National Science Board proposed a pattern of Federal support through the funding of six specific grant programs, prototypes of which exist at the present time. These six grant programs are:

- Institutional sustaining grants
- Departmental sustaining grants
- Developmental grants
- Graduate facilities grants
- Graduate fellowships
- Research project grants

At the present time, nearly 75 percent of the total Federal support to graduate education is delivered in the form of funds for Research Project Grants. The NSB study recommends a considerable revision in the distribution of Federal funding among the above six grant categories to provide support more nearly paralleling the actual needs of the six categories. The Task Force supports this view.

### The Use of Federal Laboratories

A large number of laboratories, supported almost entirely by the Federal Government, have been established over the years as the result of the clear need of certain agencies of government for scientific and technical support, or for the solution of some particular and urgent problem. These include a wide variety of laboratories reporting to various branches of the Department of Defense, laboratories for the Atomic Energy Commission, NASA, the Department of Agriculture, and some which are managed for the Government by universities.

Characteristically, each such laboratory has played a very worthwhile role. However, time and changing national needs require a more thorough reappraisal than generally has been achieved to date. There is presently no mechanism by which to appraise, on a broad basis, the virtues of the current and future support of such laboratories in competition with other needs and aspects of science funded elsewhere in the Federal Establishment. In similar vein, there is no adequate governmental mechanism for being sure that laboratories set up to serve a given branch of Government or field of activity are, after some years, still serving with directness and efficiency.

An important problem is the extent to which these Fedearl laboratories are limited by the missions of the sponsoring agency.

The provisions of Executive Order 10521 (7) authorize the "conduct and support by . . . Federal agencies of basic research in areas which are closely related to their missions . . ." and recognizes that such basic research is "important and desirable, especially in response to current national needs, and shall continue." Our mission-oriented agencies will always need research and development laboratories to carry out applied work specifically aimed at the relatively short-term objectives of the agency. There are perhaps some Federal laboratories whose current activities are only peripherally related to the mission of the sponsoring agency, and which could be renovated to advantage and reoriented toward the technical aspects of other major national problems.

A similar point was made two years ago in the National Academy of Sciences report on Applied Science and Technological Progress (10), which observed that the large interdisciplinary applied research establishments of the Federal Government comprise an important national resource that undoubtedly ". . . could perform with great effectiveness in a variety of contemporary scientific fields, some within the purviews of Government agencies other than their original parent organizations."

It should be noted, however, that many of our Federal laboratories continue to work on problems that remain extremely important to our national welfare and security, even though their work may at the moment seem less than fashionable. It would be a national catastrophe if our capacity to discharge our responsibilities in such areas as defense, space, and nuclear energy were jeopardized by the premature shut-down or redeployment, on too large a scale, of the institutions that now have the responsibility for research and development on these continuing problems of science and technology.

Finally, it seems clear to the Task Force that Government science policy should avoid encouraging the development of completely self-contained capabilities within Government sponsored, mission oriented, research institutions. These laboratories should be encouraged to develop and utilize both university resources and those of independent suppliers who market their technical services and products to users within the Government and elsewhere. Such a policy not only increases the flexibility of the laboratories, but also assists in diffusing technology and thus contributes to other objectives.

This is obviously a complex matter and cannot be resolved in general terms. However, the Task Force believes the time is ripe for a comprehensive review of the role and future plans of the Federal laboratories, with a view towards reaffirming the mission and plans of some, redeploying some in whole or in part, and closing down others, if necessary.

There have been previous surveys of some of these Federally supported laboratories, particularly those within the Department of Defense. How-

ever, the Task Force believes that previous efforts have not been adequately vigorous or far-reaching.

## Priorities in Federal Support of Basic Science

The budgetary process for Federal support of basic and applied research is in need of modification to provide a more accurate and better-integrated view of the funds being spent by the Government for this purpose. It is also desirable to provide a more deliberate relationship between the levels of funding for various categories of research and the priorities for such research.

The present budget categories give an erroneous view of the amount of money being spent by the Federal Government on basic and applied research. Begining in 1961, many activities which had been carried in the Federal budget under procurement, operating, and maintenance accounts were placed into the RDT&E account. In the Department of Defense, this increased the research and development (RDT&E) account five to six-fold over the amount previously categorized as R&D. To most people, "R&D" represents basic research, work in laboratories, and limited experimental hardware which, in previous budgets, were the activities essentially covered by the R&D budget. It is understandably confusing to legislators and to the public to hear that the Federal Government spends more than $17 billion per year for "research and development" when in fact only about 9 percent of that amount is spent for basic research and only about 17 percent for applied research.

The funding of scientific projects through many different Federal agencies, under the cognizance of many different Congressional committees, leaves a diffcult problem of determining priorities among projects and agencies, and matching the funding accordingly when total budgets must be carefully cotrolled. It has been relatively simple to order priorities and funds within a given field of science (e.g., telescopes for optical or radio astronomy, different kinds of accelerators for high energy physics, various projects within bio-science, and projects within the social sciences), but budget decisions are in fact being made—particularly in tight budget years—*between* these fields. For example, whether to construct the Batavia accelerator, or to operate a synoptic world network of oceanographic stations, or to resurface the Arecibo telescope; whether to build new oceanographic ships or place some in mothballs, or fly biosatellites and a number of instrumented probes.

No one agency other than the Budget Bureau itself is asked to consider *all* such questions, or to order them in scientific priority as well as in the prospects for early societal benefit. No agency is asked what would be the best use of the next increment of, say, $50 million, in view of the

total picture of Federal support for science. Nor is any one Congressional committee so concerned. Accordingly, since such decisions must be made, each is made ad hoc within an agency independent of the others and with only the concurrence of its own cognizant Congressional committees, with little or no consideration of events occurring in the remainder of the system.

The Federal Council for Science and Technology has shown that it is an excellent forum for communication but in the past it has not been effective in joint planning. Management of specific science projects in several agencies has improved since the creation and appointment of Assistant Secretaries for Research and Development, but overall Federal planning and management have not. Whereas the Office of Science and Technology, with enlarged staff, could weigh the many complexities of these problems and recommend policies or decisions, difficulty in securing agency compliance and Congressional cooperation would remain.

**Recommendations**

The Task Force recommends that the President direct the Office of Science and Technology, in coordination with the Bureau of the Budget, and with the advice and cooperation of the Executive Departments and the National Science Foundation, to develop improved machinery for the integrated management of direct Federal support of basic and applied research. This effort should be related properly to long-range projections of total national interests and requirements, and should include Congressional approval as needed. To accomplish this general intent, the Task Force recommends that:

1. The level of support provided to the National Science Foundation and other basic research agencies (e.g., the National Institutes of Health) be increased as rapidly as feasible. A level of support of approximately 0.1 percent of the gross national product (GNP) is suggested as a reasonable level for support of the National Science Foundation, to be achieved as soon as possible. The level of support should permit the NSF to be responsible for approximately one-third of all Federally supported basic and academic research. A transition phase extending over several years may be necessary to insure continuing support (without reductions in total levels) of projects and facilities which should be supported nationally and phased out of mission agencies. Great care must be exercised to maintain close connection between each mission agency and basic research in areas which can reasonably be expected to bear strongly on that agency's problems. This would mean continuing support of considerable basic research by mission oriented agencies and avoiding too narrow an interpretation of the relevance of such research.

2. A specific program be developed and proposed to the Congress in general accord with the National Science Board report (8) on Federal support of graduate scientific education. Key steps in implementing this program should receive legislative authorization and initial appropriations not later than fiscal year 1972.
3. A review be made of the role and future plans of all Federal laboratories. Such a review should be carried out by a commission made up primarily of persons outside the sponsoring agencies, and possibly organized through the cooperative efforts of the President and the Congress.
4. The Office of Science and Technology be designated by Executive Order as the principal organization within the Executive Branch for establishing the priorities among the various competing scientific research programs and major projects which will be considered in developing the Federal budget to be recommended to the Congress, beginning in fiscal year 1972. In accomplishing this task, the OST, in close coordination with the Bureau of the Budget, should receive the advice and cooperation of the Executive Departments and the National Science Foundation, and should seek advice from outside the Government, including the National Academy of Sciences and the National Academy of Engineering.

## *Stimulating Technological Innovation by Private Institutions*

Private institutions should be encouraged more strongly by the Government to invest capital and scientific and technological resources in the development of solutions to urgent social, urban, and environmental problems. This requires a more sharply focused pattern of incentives for such investment—incentives which may derive either from the Government's purchasing power or from its legislative and regulatory authority, or both. These incentives should be developed and applied, as appropriate, to business, labor unions, foundations, professional organizations, colleges and universities, and other private institutions. An enormous potential exists for removing the deterrents, the uncertainties, the instabilities, the lack of visibility, and the institutional rigidities which operate to block effective participation in problem solving and in constructive programs.

*Source of Technological Innovation.* The largest and most effective machinery for technological innovation in the Nation is provided by our system of business enterprise. It is therefore essential that this powerful machinery be directed to the expanding social, urban, and environmental problems which we have discussed in this report. This objective requires particular Government policies and particular Government action in stimulating and guiding the application of business management, capital, and technological resources into areas not currently served sufficiently by the established market forces. This is particularly true if one projects our present problems for ten or twenty years into the future.

A recent report on technology and society (2) discusses the new problems created by the "shift in the composition of demand in favor of public goods and services—such as education, health, transportation, slum clearance, and recreational facilities—which, it is generally agreed, the market has never provided effectively and in the provision of which the government has usually played a role of some significance. This shift in

demand raises serious questions about the relationship between technological change and existing decision-making structures in general and about the respective roles of government and business in particular."

Industry is conventionally and properly seen as a source of charitable contributions to assist in urban and social problems and as a source of participation and support in urban action programs (e.g., the Urban Coalition, the National Alliance of Businessmen). In addition to these roles, however, industry has a much more significant and critically necessary role in applying its resources more directly to these problems. The Government must recognize this role and the importance of stimulating private industry to see our pressing social, urban, and environmental problems as new and attractive marketplaces.

Industry is very flexible in its ability to change quickly, divert and redeploy resources, and generally seek out and apply talent to problems where clear market opportunities are likely. Similar flexibility has not been demonstrated by either Government or universities. The most common examples of successful interdisciplinary team projects are those found in industry. This experience is particularly applicable to those large and complex social, urban, and environmental problems of a "systems" nature.

*Creating New Markets.* It is not sufficient merely to observe that the marketplace is currently inadequate for certain needs of our society. Because the marketplace does not presently serve certain needs effectively does not mean that the only alternative is massive Government sponsorship and massive new investments by Federal or state government. What is missing in such a conclusion is adequate recognition of the Government's ability and responsibility to create new market opportunities that are pertinent to the needed goods and services of our society, in order that the power of the business enterprise system can in fact be applied to these problems. What the Government can and should do is use its purchasing power to sponsor selected research and development, its regulatory and standard-setting authority to establish criteria, its taxing authority to provide special incentives, and its leadership to help remove the deterrents (such as lack of market visibility or unnecessarily restrictive practices) which discourage or prevent private industry from making capital and technological investments in these areas. A principal deterrent to such private investment currently is the highly unstructured and unstable nature of the "civil market." Hence, a key objective of Federal policy in this regard should be to define plans and programs of sufficient duration and of sufficient certainty to provide visibility and confidence to the potential entrepreneur.

The Government should also help to define aggregated markets (as, for example, the Department of Housing and Urban Development is now doing with its low cost housing project, Project Breakthrough), and should sponsor selected demonstration projects to help expose the profit-

making potential in the provision of critical urban services or improved educational and health care facilities and services, for instance.

*Need for Private Investment.* Enormous resources of management, technology, dedicated people, and money are required to support technological innovation on the required scale. The total amount of money which can be made available from all Federal sources will certainly be inadequate; greatly increased private investment will ultimately be essential if we are to solve the pressing urban and environmental problems of the present and future. Government sources can fund the "enabling" activities, but the "bulk resources" must come from the private sector. This, then, is the basis for the requirement to convert "needs" into "market opportunities." In the end, the Government's money, while important, may be less significant than its leadership.

A strong economy and a prosperous industry will help promote a continuing effort of industrial research and technological development aimed at new civil markets. Once properly started, the effort is essentially self-generating and self-perpetuating, and the competitive aspects of business and industry largely assure continuing action.

*Technology Transfer.* Since a rapid rate of technological innovation and technology diffusion is a key ingredient in economic development, Federal agencies engaged in conducting or sponsoring research and development activities should attempt to shape their policies with due attention to their possible economic implications, particularly including the transfer of technology from the immediate purposes of the agencies to other purposes and goals of the civilian economy. In order to foster such technology transfer, large broad-activity Federal research institutions should regard it as part of their function to encourage other Federal agencies, and institutions in the private sector, to use the technology which has been developed.

**Recommendations**

The Task Force recommends that the President enunciate a national policy of increasing long-term participation by private institutions—particularly business—in social, urban, and environmental programs.

It is also recommended that the President direct the appropriate Departments and Agencies of Government to establish broadly-based efforts to identify systematically the deterrents to private investment of capital and technology in social, urban, and environmental programs, and to suggest specific incentives for action and remedies for each such deterrent.

# *Science Policy as Related to National Security*

The United States is entering an era of profound problems as we look to the seventies and beyond. This is an era of relative strategic balance with the Soviet Union, of the emergence of Communist China as a nuclear power, of increased unrest among the non-nuclear nations and increased temptation toward confrontation and escalation, of the historic possibility of achieving verified nuclear arms limitation agreements, and of unusually intense budget pressures.

These significant new factors dictate the need for special attention to the following general aspects of science policy for national security purposes:

1. *Avoidance of technological surprise.* Technology will not stand still; on the contrary, it will likely move more rapidly. The penalty for technological surprise can be enormous.
2. *Reducing lead-time for reaction to changed circumstances.* The capability to react quickly to significantly changed circumstances—changes in perception of Soviet intentions, for example—will become even more critical than it has always been.
3. *Increased emphasis on intelligence and reconnaissance information.* In a period of relative strategic balance, it will be more important than ever to have the best possible information on what is happening behind the "Iron" and "Bamboo" curtains. The margin for error will be significantly reduced, and the premium on precision will be increased. Obviously, the need for continuing verification of nuclear arms agreements further emphasizes this point.
4. *Reduction in total costs.* The increased performance requirements for military hardware, the effects of inflation, and the budget pressures all dictate renewed attention to the matter of cost reduction.

All four of these points lead to the need for increased emphasis on research and development in relation to other competing national security activities. In guarding against technological surprise, it is vital that high-risk long-range research and development programs in critical areas be sustained. The greatest single contribution to reducing lead-times for quicker reaction to changed circumstances would be a development program which emphasizes the bringing of critical high-technology sub-

elements of new weapon systems to the demonstration phase on a continuing basis. The significance of research and advanced technology for the purpose of dissolving the "Iron" and "Bamboo" curtains is apparent. Finally, direct research and development projects aimed at cost reduction are indicated: for example, development of "design for low cost" techniques, inclusion of ultimate cost in original research and development specifications, competitive research and development projects where demonstration of low cost is a primary objective.

The impact of the generally rising anti-science and anti-technology attitudes discussed previously in this report could have a particularly important effect on the correct military research and development program for the Nation. The issue of national security research in our universities, for example, has become an irrational one with many students and many faculty members alike. Attacks on the military-industrial complex have, in too many cases, become narrowly self-serving and very short range in perspective. The need for better public and Congressional understanding of both the limitations (e.g., lead-times) and the nature and importance of science and technology for national security purposes is very great indeed.

**Recommendation**

The Task Force recommends that the President enunciate a national policy of increased emphasis on research and development for national security purposes—even at the expense of current military hardware procurement if necessary.

# *International Initiatives Utilizing Science and Technology*

The intrinsic nature of science results in unusual opportunities for international scientific cooperation and assistance. The language of science is nearly universal. The demonstrated ability of scientists to achieve mutual understanding on scientific matters across international boundaries suggests the prospect of extending such understanding to the political and economic fields. It is apparent that much of the world views the United States as the leader in scientific and technological training and innovation; this opinion, supported by visible programs, has in the past and can in the future significantly enhance our foreign policy opportunities.

Some technological enterprises—the space program, for example—offer unusual opportunities for foreign policy and international initiative. The dramatic worldwide response to the Apollo 11 and Apollo 12 triumphs are outstanding examples of technological projects creating foreign policy opportunities. Universal human interests crossing all international boundaries—in agriculture, health, clean air and water, education, and communications—all suggest similar though more diffuse opportunities.

Many of the present world problems—overpopulation, pollution, and provision of nutritional and energy resources increasingly will expand and trouble the United States, thus making the world's problems indivisible from our national problems. "Science for Mankind" will increasingly represent not just a slogan but a reality in our international affairs.

*Assistance to Under-developed Nations.* It appears to the Task Force that the Federal Government is presently making insufficient use of our extensive scientific and technological capabilities as instruments of foreign cooperation and understanding. It has been an essential item of U.S. national policy to assist developing nations around the globe, but this has been done primarily by grants of capital assistance rather than by technical assistance. It is encouraging that the significance of technical assistance appears increasingly to be recognized, however.

The question of international technology transfer—the delivery and application of scientific and technological knowledge, methods, and techniques from one nation to another—is one which the United States should give very searching consideration in its formulation of a more effective science policy. There are many facets of our advanced scientific and engineering technology which can indeed be transferred "bodily" to other nations. But it is unlikely that indiscriminate efforts to transfer technology will be effective; technology, to be useful, must be related properly to local environment and cultural and economic restrictions. Advanced agricultural techniques which are of great importance in the United States may have little or no effectiveness in a country where the pointed stick is one of the most widely used farm implements.

The Task Force believes that much greater emphasis must be placed on the transfer of research and development capabilities, rather than of technology itself, if we hope to increase the effectiveness of our assistance to underdeveloped countries. We must place stress on the transfer of methods for technical research and education within the ethnic and environmental framework of the receiving country itself, rather than within our framework.

As an example of a current opportunity for improving the effectiveness of our assistance to underdeveloped countries, the Task Force believes that the area of scientific education and technical training offers significant potential. The limitation upon the genuine benefit of capital assistance to a developing nation is its cadre of trained and knowledgeable individuals capable of continued operation of a new facility, whether it be a power plant, a factory, or an agricultural station. Many such emerging nations have a small cadre of highly educated individuals who have been trained in the universities of the developed nations, but totally lack the technicians required for continuous viability of a technical operation. Moreover, most such nations have few if any institutions capable of producing either technicians or advanced scientists and engineers.

On the other hand, the United States has invested substantially in the development of curricular materials in almost all areas of science and some in engineering. These include, in particular, the materials for instruction in high school science and mathematics. At relatively modest cost such materials can be translated into the indigenous language of a developing nation and appropriately trained Americans can accept responsibility for their introduction into local educational systems.

The Task Force believes that an enlarged program of educational assistance in areas of science and technology should be made an essential element in our foreign aid program. This would require only a small fraction of AID funds coupled to the existing capabilities of the National Science Foundation which has served our country in the same regards.

Joint AID–NSF ventures have already been extraordinarily successful in India and Brazil although they have been extremely limited in size and scope. Technical education is the key to entry into the 20th century for a developing nation. Without it capital assistance is often wasted; with it a limited amount of capital assistance could be extraordinarily valuable.

**Recommendations**

The Task Force recommends that the President continue to encourage the major Departments and Agencies of Government to suggest specific new science-based foreign policy initiatives and opportunities for international cooperation.

It is also recommended that the Administration make clear a policy of technical assistance, with increased emphasis on the needs of underdeveloped nations, which will help them build their own institutions of scientific research, education, and technical training.

# *Continuing Development of Science Policy*

The Task Force has been acutely conscious of the short time available for its work, and has recognized the complexity and pervasiveness of national science policy as such policy has evolved over the past one hundred, and particularly the past twenty-five years. Hence, the final issue which we have addressed is the matter of the formulation of science policy itself. The machinery for the continued development of national science policy, both in the Executive and the Legislative Branches of the Government, needs explicit additional attention, both now and on a continuing basis. This section of the report discusses some of the considerations related to continuing development of science policy.

## General Background

The formulation of national science policy is both exceptionally complex and exceptionally important; science policy should be dynamic, with evolving and shifting emphasis required; it is far-reaching and pervasive in its significance and impact; it is large in scale, influencing an important fraction of both public and private expenditures; and it is a very active subject. As examples of recent activity, the 90th Congress passed 94 public laws authorizing, funding, or otherwise affecting research and development in the United States, and also took legislative action on 45 other bills relating to these matters. In all, 32 Congressional committees held 327 hearings on various aspects of public policy for science and technology. The 90th Congress received 212 related statements from the President (11).

*Broader Participation.* It has been observed that a specific deficiency in the way we arrive at national goals and priorities is that the science and technology inputs come mainly from universities and non-profit organizations. Formulation of national science policy should seek wider participation from private industry, labor, and the professions. The establishment

of internal priorities in science itself; that is, priorities in basic scientific research, can probably best be suggested by practicing scientists. Priorities for applied science and for technology require full participation by individuals experienced in politics, economics, management, engineering—experts well versed in the uses of applied science and technology.

*Recent Science Policy Studies.* It is interesting to note that two of the most comprehensive recent studies of U.S. policy for science and technology were prepared not by U.S. organizations or agencies, but by international organizations: The Organisation for Economic Cooperation and Development (OECD), and the United Nations Educational, Scientific and Cultural Organization (UNESCO). Among their observations are the following:

> The development of American science policy has never taken the form of a deliberately ordered enterprise. Policies for agriculture, defense, nuclear energy, space, fundamental research, and even education have all been superimposed upon one another. The overall effort is nonetheless significant and spectacular (12).
>
> It is impossible to single out from the political mechanism, agencies capable of giving a unified drive to the whole enterprise (12).
>
> Scientific and technological activity has nevertheless been most fertile, unquestionably dynamic, and has shown undeniable aptitude in following the guidelines laid down by the Government. This success was made possible only by the spirit of competition and vigor of pluralism (12).
>
> The resulting plurality of science policies provides the opportunity for extensive discussion of major issues that tends to insure against mistakes caused by undue dominance of a single point of view. However, this same plurality often increases the difficulty of coordination and of the achievement of a coherent national perspective on the development and utilization of scientific and technological resources (13).
>
> The number, magnitude, and importance of the [scientific and technical] programs proposed means that new priorities must be set between different possible goals; but this is made very difficult by the specialization of the bodies responsible for the scientific undertaking in both the legislative and executive branches (13).
>
> The internal organization of Congress makes it difficult for the legislative branch to exercise direct overall and lasting influence over the research and development programs of the executive branch. . . . The tangled network of congressional responsibilities in this field may hamper and slow down the normal legislative work of formulating alternatives to the proposals and activities of the administration (13).
>
> This state of affairs does not make the task of the executive branch any easier. Within the administration, apart from new, high-priority

undertakings, the budget process appears to favour the long-established programmes rather than the relatively recent ones. This is inevitable: the rapid growth of the main Federal programmes constitutes a commitment which weighs heavily against new undertakings (13).

We looked in the United States for a science policy; in fact there are many. But what we did find, in the formulation, implementation and achievement of these policies, is first and foremost a convergence of interests and motivations to construct the future; the adventure of scientific and technical research appears as the main way of access to this future in which the drive and ambitions shown by a whole nation will be expressed (12).

**Regional Goals and Responsibilities**

In developing national science policy, both central and distributed (i.e., regional) national goals must be considered. The distributed goals should be of such a nature as to aid all regions of the Nation to satisfy their needs in such fields as education, transportation, delivery of public health services, law enforcement and the administration of justice, clean air and water, and housing and urban development.

Government at al levels, as well as private organizations, should be involved in the decision making process as it relates to the establishment and achievement of these regional goals. All levels of government should similarly be involved in providing the funds necessary for the support of research and development aimed at the solution of these problems. In many parts of the country, R&D is well supported at present, while in other areas, support is minimal or deficient. It seems likely that significant new R&D programs will be required in pursuit of these regional goals within the next decade.

Institutions which provide such widely needed services as education, health, and law enforcement, among others, will require increasing support and expanded innovative approaches to meet the needs of the future. Such programs of support should be approached in pluralized, decentralized ways, both geographically and institutionally, rather than through highly centralized direction and management.

A study was recently completed by the NAS/NAE Committee on Science, Technology, and Regional Economic Development (14). This study concludes that national policies for regional economic development should have two primary objectives:

1. To improve incomes and levels of living in regions by making it possible for people in each region to increase their contributions

to the national economy through development of the region's comparative advantages and full utilization of its manpower and other resources.

2. To assist in correcting major imbalances in the availability of social and economic opportunities among some parts of the nation and between some regions and the country as a whole.

The report further observes that ". . . increasing support and utilization of R&D by the federal government has not been matched by a corresponding trend in state and local governments. Mechanisms are needed for encouraging both centrally directed research and locally oriented research on such problems as law enforcement, urban development, and waste disposal."

Problem oriented studies of urban and environmental problems which are of particular importance and concern to local regions should be initiated. Such studies should be conducted with the assistance and participation of regional institutions, such as local industry, local unions, and local universities and research institutes. Typical examples of such problem oriented studies which are applicable to various regions of the country are the motor vehicle-induced air pollution in Los Angeles, the water pollution of Lake Erie, and the waste disposal problem in New York City. Such Federally sponsored, locally performed studies could provide basic guidelines and courses of action for attacking similar problems in other local regions throughout the United States by the application of joint Federal and local efforts.

## Distinctions and Definitions

There is a temptation to generalize and oversimplify when considering the various aspects of science and technology. Shortcuts in terminology and usage tend to give insufficient weight to important distinctions between "basic" and "applied"; between "science" and "technology"; between "academic," "government," and "industrial"; between "research," "development and test," and "production". Without including at this point a discussion of definitions (see References 10 and 15), it should still be emphasized that essential distinctions must in fact be made to arrive at wise policy and management decisions. Properly applied, these essential distinctions will lead to different perceptions of purposes, of sources of financial support, of the kind of institutional support required, of the methods of management and control, and of the time frame for the expectation of results, for various parts of the whole of science and technology.

## Relative Distribution of Effort: A Science Policy Question

The present national budget includes about $1.5–2 billion for the support of research, $15–20 billion for technological development, and very approximately $150 billion for goods and services strongly dependent on technology. These expenditures represent a ratio on the order of about 1 to 10 to 100 in outlays for research, development strongly affected by research, and procurements affected by both. While it is difficult to establish with any precision the most appropriate levels of support of research and development, examination of these ratios can perhaps delineate some useful guidance.

There is no doubt that if the United States is to maintain its economic and military strength, and remain one of the world's greatest nations, its science and applied science must compete successfully with that of other nations. We cannot for example, afford to compete on a pure manpower basis with a number of the highly populated nations, but must continue to rely on a substantially higher level of skill and knowledge.

Any view of the balance between research, development, and production must be somewhat subjective, and dependent on experience with actual cases. However, it is clear that since the present cost of research represents such a small fraction of the cost of development, transfer of a small part of the funds (e.g., 5 percent) from development would greatly increase research funds (e.g., by 50 percent), so that if research is in fact having a substantial beneficial effect on development, such a transfer may bring us closer to optimum use of funds. A similar transfer from production to research might be useful.

Policies must be laid down which carefully consider the appropriate balance of effort in these three areas and prevent their temporary distortion due to the frequently occurring pressures for rapid results. In the continuing development of national science policy, the relative distribution of effort between the three areas of research, development, and production should be carefully examined. As has been suggested in an earlier section of this report, the level of effort for basic research should be set in proportion to our gross national product.

## Recommendation

The Task Force recommends that the President direct his Science Adviser to develop, for the President's approval, a broadly-based program for the continuing development of national science policy. This program should provide for full participation by individuals from both within the Government and from outside the Government, experienced in politics, economics, maangement, labor, and engineering, as well as practicing scientists and science administrators.

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